

amber_kinetics

DOE Peer Review

September 2012
Ed Chiao, CEO



Amber Kinetics: Our Flywheel History

Stanford University

Start-up launched in 2009, Stanford University Cleantech Entrepreneurship class

**Lawrence Livermore
National Laboratory**

Established a technology licensing & flywheel development partnership with LLNL; Amber Kinetics identified new material & lower-cost rotor designs for commercialization

**U.S. Department of
Energy**

Awarded a Smart Grid Energy Storage Demonstration grant award for flywheels

**California Energy
Commission**

Awarded a matching grant for development & demonstration of flywheel technology



SIEMENS

World-class institutions | **innovative, deep** flywheel technology **owned** by Amber

Program Schedule

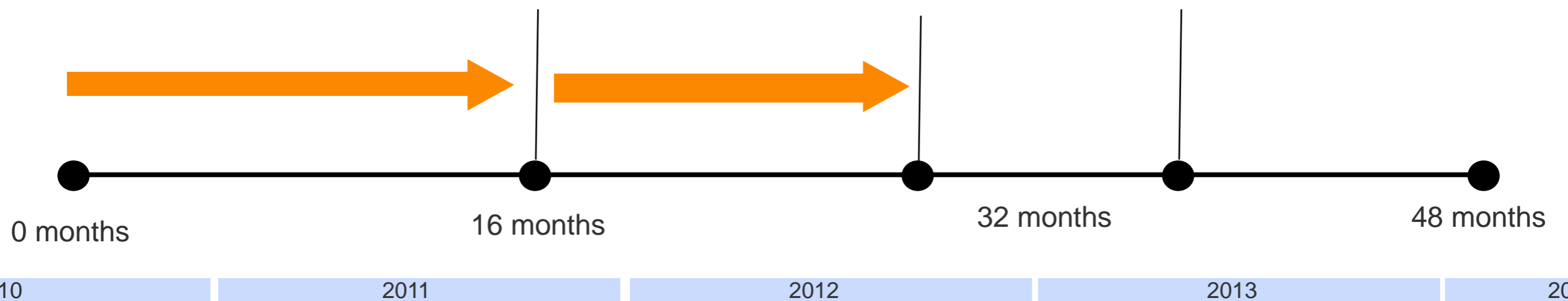


Technology Milestones
Prototype Proof of Concept

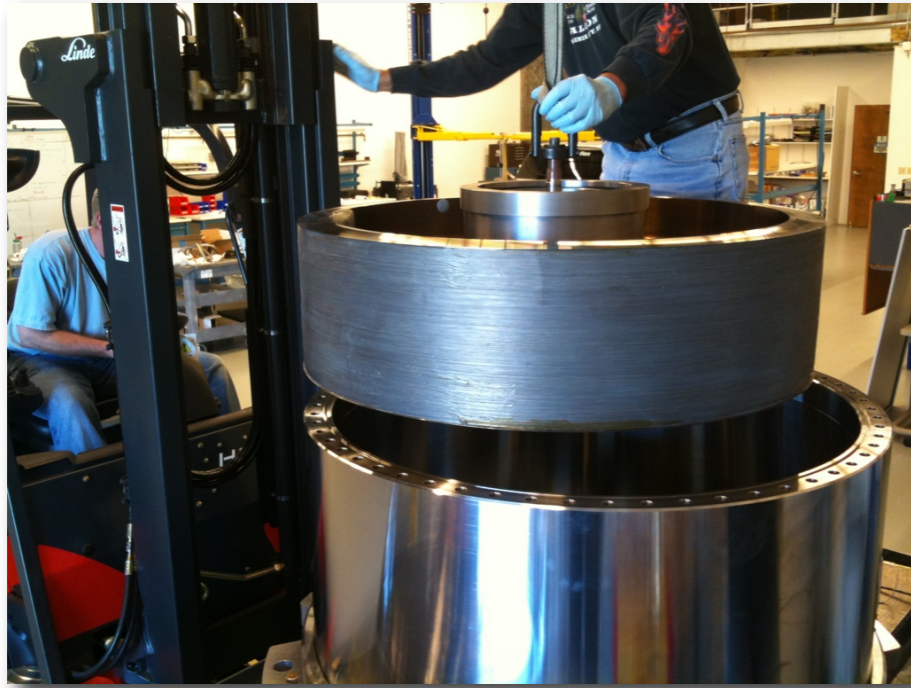


High Cycle Testing
Commercial-Scale R&D

Commercial-Scale
Flywheel System



Technology Milestone #1 – Spin Testing



Spin Testing

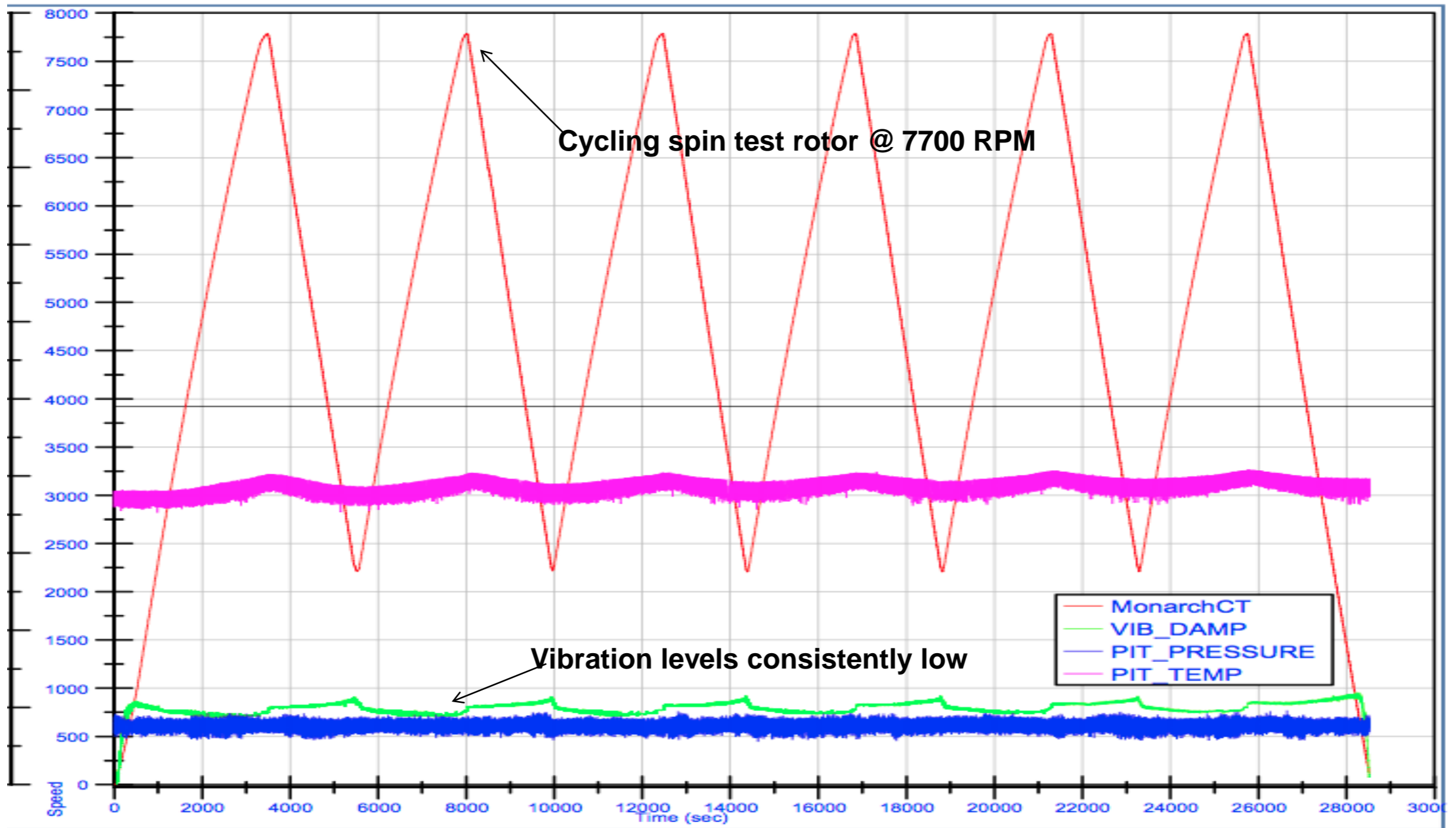


Reinforced Spin Pit Assembly

- **Two 750-lb flywheel rotors constructed**
- **Maximum operating design speed: 365 m/s and 7700 RPM**
- **Spin testing accelerates rotor to: 530 m/s and 11,000 RPM**

- **Rotor stores 10 kWh of kinetic energy @ 11,000 RPM (2x more than design speed)**
- **All testing conducted in start-of-the-art spin testing facility in Hudson, MA**

Spin Test Cycling Results



Technology Milestone #2 – Flywheel System Activation



Generation One: Prototype 20 kW | 5 kWh Flywheel System



5 kWh, steel wire-wound flywheel rotor activated & operating in prototype system

Technology Milestone #3 – Fatigue Testing Results

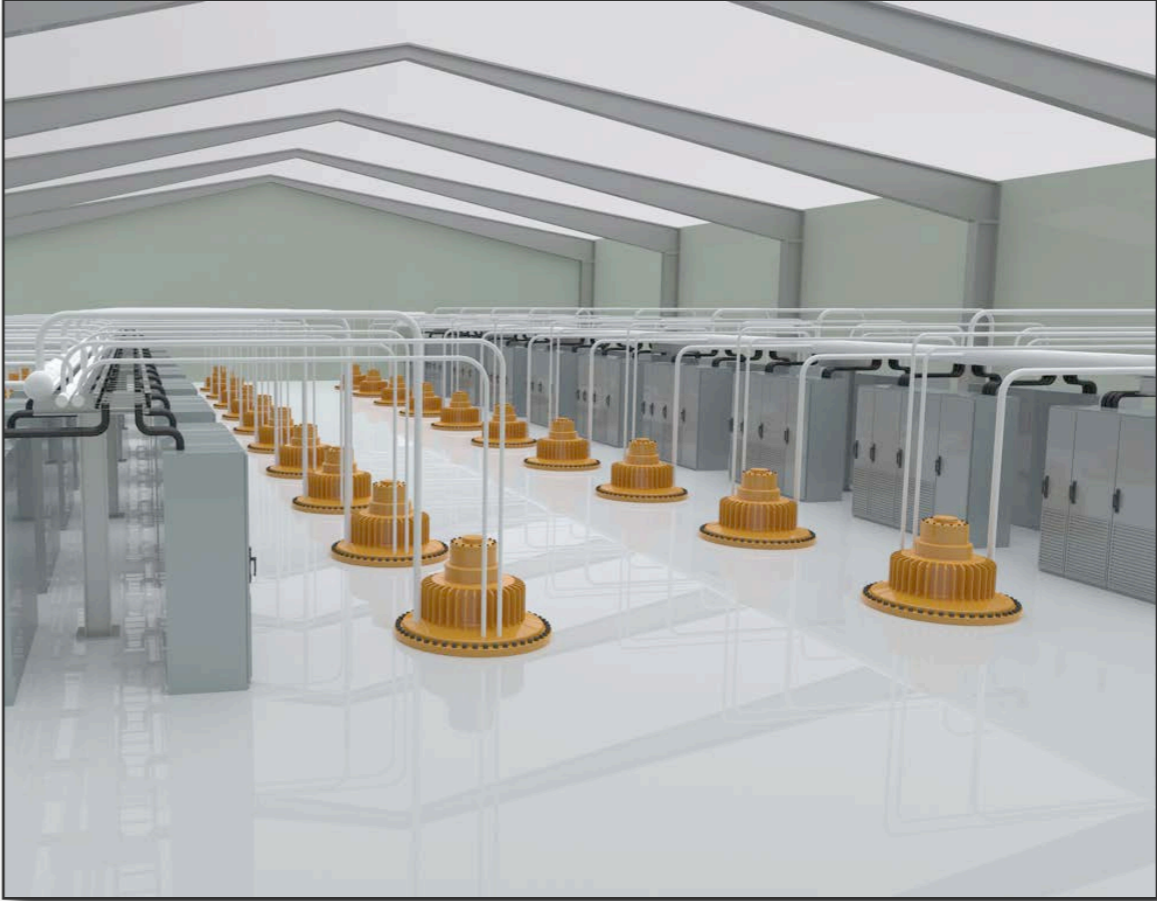


- Observed over 350,000 test cycles
- One cycle tests from 0-100-0% of operating design stress
- Testing across a pre-defined range of material specs
- Testing across multiple supply vendors
- Material cost: ~\$0.50 per pound, simple to MFG
- 1/20th the cost of carbon fiber
- Material sources are mature; rotor design is scalable

Commercial-Scale Flywheel System & Facility Design



Amber Kinetics 500kW | 125kWh
Generation 2 Flywheel



20 MW Facility
10,000 sq ft Building

Challenge - High Balance of System (BOS) Costs

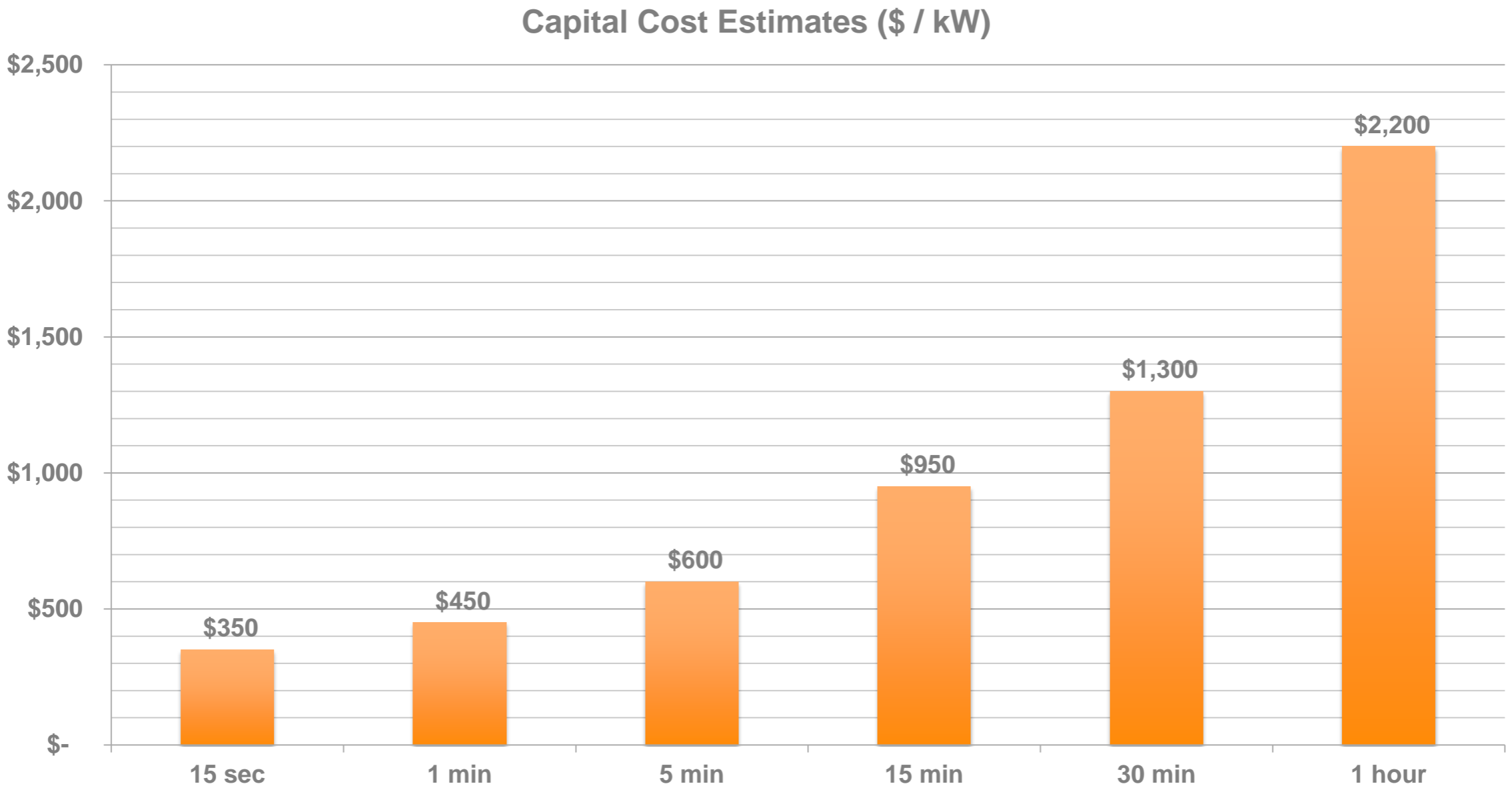


Dimensions: 5 ft x 12 ft (Diameter x Length)

- Vacuum Vessel
- Upper & Lower Stator Support Assemblies
- Motor-Generator System
- Magnetic Bearing System
- Upper & Lower Touchdown Bearing Assemblies
- Power Converter & Control Electronics
- Temperature & Position Sensors
- Ancillary Components
 - Vacuum Pump
 - Vacuum Feed-Through
 - UPS
 - Motor & Bearing Drives

BOS costs generally scale with respect to physical size & weight of the machine

Capital Cost Estimates (AC-to-AC)



Cost estimates based on point designs for a 125 kWh flywheel system

Conclusions:



< **1/2** Capital Cost (\$ / KW)
vs. traditional flywheels

- Flywheel rotor costs represent a cost breakthrough
- Balance of System costs dominate flywheels
- Project partners have helped Amber Kinetics evaluate aggressive BOS cost reduction
- Preliminary cost estimates for long-duration storage systems are higher than anticipated
- Project requires identification of a clear application for which flywheels can prove to be economically competitive

thank_you

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